HOW TO SOLVE
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BY

DR. RICHARD MOLDENKE

LECTURE No. 34

OF THE

FACTORY MANAGEMENT
COURSE AND SERVICE

VOLUME 9, LECTURE 2

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Dr. Moldenke graduated from the School of Mines, Columbia University in 1885 as Engineer of Mines, receiving the degree of Doctor of Philosophy from the same university in 1887. In later years he served as Professor of Mechanical Engineering, Michigan Mining School; in the United States Coast & Geodetic Survey; as member President Roosevelt's Advisory Board for Geological Survey; as Foundry Expert for Bureau of Mines; as Vice President to one of New Jersey's State Boards, and as Director in many mining and industrial corporations. He has also served as consulting metallurgist specializing in Cast and Malleable Iron, and has been connected with many large manufacturing establishments operating foundries in a consulting capacity. Dr. Moldenke is a member of Amer. Inst. Mining & Met. Engineers; Amer. Soc. Mechanical Engineers; British Iron & Steel Inst.; Amer. Soc. Testing Materials; Amer. Electrochem. Soc.: an honorary member Amer. Foundrymen's Association, British Foundrymen's Asso., and foundrymen's associations of New England, Pittsburgh and Newark. He is the author of many papers on foundry practice, a book on "Production of Malleable Castings" and a later book on "Principles of Iron Founding."

HOW TO SOLVE FOUNDRY PROBLEMS

By Dr. Richard Moldenke

Importance of Good Management.—Few situations in industrial management involve such a mass and variety of detail based upon sound knowledge as the operation of a foundry. To be a successful manager, independent of trained assistants if need be at a pinch, considerable reading and study is essential to master enough of the elements of mechanical engineering and metallurgy to serve. This apart from the general study of economics and scientific management, and all of it is necessary in order to understand and direct every department of the complicated industrial fabric called the foundry. Not only must every wheel of what may be a huge industrial machine function correctly in the conversion of piles of pig iron and scrap into servicable castings, but these piles of raw material must be bought with foresight and economy and the castings utilized or sold to best advantage. With favorable location and markets the successful foundry manager can build up a wonderful industry in a community, and be an important personality therein.

Considerd from the managerial standpoint, there will be two kinds of foundry development to study;

namely, the foundry forming part of an industrial enterprise, and the independent jobbing foundry. In each case, the foundry may consist of one or more divisions of the art, such as the making of gray iron, steel, malleable, brass and bronze, and aluminum castings. Each class of work has its own peculiarities, characteristics and requirements, but they are all amenable to the same line of operative attention from the managerial standpoint, and what follows applies equally to gray iron castings as to the others.

The usual development of a foundry forming part of an industrial enterprise came from a jobbing shop which branched out into a specialty. Less frequently a manufacturing plant would grow tired of the delays and troubles with purchased castings and find it cheaper to go into the making of castings, particularly where big tonnages were involved. The ultimate trend of all foundries, however, means that the great majority of large foundries are becoming parts of equally large manufacturing establishments, and a large jobbing foundry doing no machine finishing is rather the exception today, though there exist many small jobbing foundries that hope some day to specialize in some direction.

Location and Arrangement.—The question of location and plant arrangement or of re-arrangement will constantly be in the mind of the manager, for an establishment not going through a continual process of evolution stands still or soon falls behind. Every manufacturer tells you that he hopes some day to be really turning out perfect product from a finished plant, but that day never comes to the man in the

front line of his division of the industrial procession. Questions of removing a plant bodily to a more favored locality do not come up very often, but a rearrangement of the operating units and improvement in manufacturing facilities should always be under consideration. The nature of the work may allow a routing of raw material to finished product which suggests a top-floor foundry with adequate economic raw material hoists, and a succession of downward movement of the product in its several manufactured stages to the distribution point of the finished work on the ground floor. This is particularly the case in large cities with such castings as soil pipe and fittings, hardware, and where many items must be stocked and distributed in variety and in small lots.

The important fact to be remembered by the executive head of a manufacturing enterprise is that the arrangement of a foundry usually considered essential should not be a deterrent in planning out the most economic system of operating the plant as a whole. Many things can be done with a foundry that appear inadvisable at first glance, but which on closer study can be worked out successfully and harmonizing with the general plan in view. The foundry need not necessarily be a stubborn fact which must be handled either one way or not at all. If the general scheme calls for a foundry on the sixth floor, put it there and work out the necessary details of operation that will ensue. If the plan calls for continuous operation, arrange the labor end to suit the conditions, for persistency in this will win out in spite of apparently unsurmountable difficulties. If large instal-

lations of labor-saving machinery prove advisable, put them in, but do not make the common mistake of expecting results without brains to operate them efficiently. Make the foundry factors fit your plan if this is based on correct principles, rather than make your plan to fit the foundry factors. One does not realize how readily foundry factors—such as molding, melting and finishing processes—yield to intelligent and advanced ideas of arrangement and operation until one tries. This is real empire building by advanced thinkers in the industrial field.

Fundamentals of Successful Practice: Material.—Before taking up the discussion of problems in foundry routine, it is well to point out the three fundamental requirements of successful foundry practice. These are: first, the necessity of stocking up with good raw materials. Only well made pig irons are desirable; "off" irons usually mean trouble, except when used for special purposes. Similarly the scrap bought should be free from "burnt" material. Good ingot copper, brass or aluminum and corresponding scrap should be used, the only allowable situation for inferior material for making the ferrous castings being where a basic-hearth electric furnace refines the metal previous to pouring. The best of coke, molding sands, and the usual supplies for finishing molds and making cores are only good enough, for it is idle to expect good castings from poor material.

2. **Melting.**—The second fundamental requirement of successful foundry practice is to use high class methods of converting the good raw materials above mentioned into the right kind of molten metal or

alloys to be poured into properly made molds. The proper melting method should be selected and carried through with the least degree of oxidation possible. The molten metal or alloy should have the proper temperature, be right in composition, in shape for effective pouring, be properly skimmed, and go into molds which are as nearly perfect as the art of the molder can make them, the mold surfaces being properly finished off to yield good surfaces on the castings. Good material charged into the furnaces can be spoiled in the melting, hence the best of attention is required here.

3. **Adequate Gating.**—The third fundamental requirement is that the good materials, well melted and going into good molds, should be given the best possible chance to feed up properly, so that as nearly a sound casting may result as is possible in practice. This means good judgment in gating the molds. This subject alone is one for a life study, and many a veteran foundryman falls down when getting the mold for a new job ready for pouring. Unless the molten metal can be made to reach the end point of its travel direct and quickly, and remain there to set, it will not feed itself from the fresh metal behind it, gradually setting until the entrance gate is reached. The result will be liquid portions of metal imprisoned within walls of metal already set, and then the volume contraction incident to the conversion of liquid to solid metal takes place—with a bad "shrink" as the result. The subject of gating is therefore a most important one, for unless good metal, well melted, is given its best chance through the medium of proper

gates in the mold, the casting will not be reliable. These three points form the sum and substance of successful foundry procedure, and should be constantly kept in mind by the manager in locating the source of defective work. The relation of these points to the subjects of metallurgy and mechanical engineering are obvious, and emphasize the desirability of the manager to be well posted on them.

Yard Facilities.—A foundry is built for the conversion of suitable raw materials into saleable castings. The plant arrangement must, therefore, necessarily hinge upon the economical transit of the materials used in the various stages of their manufacture. Pig iron, scrap, coke, molding sand, etc., must converge from the respective places of storage to common points of assembly, so that they may perform their respective functions. This means, in the first place, ample and well arranged yard facilities for receiving and storage of the raw materials received by rail or water. Similarly, for the non-ferrous and more expensive metals, warehouse facilities with direct railroad siding connection are essential in medium to large shops. Pig iron and scrap are piled as compactly and conveniently as possible, and carefully marked for identification. The gantry crane and magnet for unloading and transfer of iron are now universally used where room is available. And there should be such room for yard storage purposes, for many times castings have been lost from a mix-up in irons due to insufficient storage space in a yard cramped by building extension.

Sand Storage.—Sand sheds, coke supplies under

cover, open bins for scrap where much of this is used, and industrial trackage for economical distribution where required mean but little in first cost, but cut down labor astonishingly. Where the foundry sand problem can be solved by storing it in a suitable basement under the foundry floor, where it will be free from frost and can be prepared for next day's work ready to be conveyed to the floors above, greater efficiency will result, costs will be lower, and the sand will be delivered to the floors in better condition for the molder.

The subject of molding sand is in itself an intricate one, for not only is it necessary to select a first-class sand, but also to keep it in good bonding and venting condition. With all the sand from the molds as shaken out—after the removal of the work—going through a rejuvenating process by the addition of new sand, and the "tempering" with water done at one point instead of all over the foundry floor, the resulting material is bound to be more uniform, the water better disseminated and strict attention to the bond and other qualities possible.

Scientific Cupola Charging.—Handling material costs money every time it is touched. Hence the several devices for charging the cupola mechanically. While all of these are suitable from the mechanical standpoint, the author believes that from the metallurgical side the only correct method of charging mechanically is where the equivalent of hand-charging is accomplished by mechanical devices. This means a straight drop of the pig, scrap, and coke, so that the layering is exactly as it would be if charged

by hand. Side-charging of the cupola is fundamentally wrong and is the cause of many lost castings from pin holes and shrinkage, for it is impossible to maintain a level bed and oxidation of the iron must result. Managers of large foundries should, therefore, use some form of charging device operated on the above principle, first advocated by the writer, which means the use of bottom-drop buckets charged in the yard, brought up and into the cupola, emptied and returned again — the pig, scrap, and coke being touched but once from yard to melting.

Labor Saving in Handling Material.—Among the more recent aids to economical handling of materials in the foundry there may be mentioned the grab-bucket operated by the regular foundry traveling crane, with which molding sand may be taken about the floors quickly, cheaply, and in quantity. Then, the small elevating conveyors operated by motor, that may be placed between a sand-heap and a large flask which is to be rammed up, whereby shoveling becomes easier and time is saved. Again, the adaptations of the small "tank" for both yard and foundry transportation; these little tractors pay for themselves rapidly and haul astonishing loads. It is thus possible to handle the transportation problem in the foundry very economically these days, and the superintendents should see that foremen are fully alive to the opportunities for saving manual labor at every point.

The Melting Process.—With materials for melting brought to the cupola or air furnace for the gray iron and malleable foundry, to the open hearth for steel,

to the various forms of crucibles for the non-ferrous metals and alloys—or to the electric furnace for all of them—the melting process should come next. It should be said here that managers should keep their eyes upon the progress made with the electric furnace. It is rapidly replacing other melting processes for the non-ferrous metals and alloys, has long been used for making steel castings, and is just coming into the malleable and gray iron foundry. The basic-hearth furnace offers the best possibilities for iron and steel castings, for there are three accomplishments to be taken advantage of: first, the tremendous super-heat obtained; next, the consequent deoxidation possible in the case of cast iron where the large carbon percentages make this effective when conditions are kept right, and last, an effective desulphurization depending upon the time allowed. The electric furnace may either do the melting from cold stock or from "duplex" molten metal taken from the cupola. The latter method is advisable as it is cheaper and only part of the cupola run need be taken for refinement in the electric furnace, for the special jobs, the balance going into regular work. The refining action of the furnace makes it possible to use lower grade stock for the melts, and hence the extra cost of the process is balanced by the cheaper mixtures.

Whatever melting process is used in a foundry particular care should be exercised to see that it is carried out as perfect in detail as can be, for here is where nine out of ten cases of trouble have their origin. All melting processes are to a greater or less extent of an oxidizing nature. One has but to scan

the analyses of mixtures before and after melting to observe this. The crucible melting process shows this least and the open hearth furnace most. Mixtures are, therefore, always calculated with this oxidation in view, so that the molten metal—with the resulting castings—may come out with proper composition.

Intelligent Supervision on Charging Platform.—There are two places in a foundry where it will pay to put young men of promise. One is on the cupola platform in charge of operations there. Whatever melting process is used, the materials going in as mixtures consist of new stock, such as pig iron, copper, zinc, aluminum, etc. remelted material, called "home" or domestic scrap — consisting of sprues, the gates, risers, lost castings and "over-iron" of a melt—and purchased or "foreign" scrap. It is important that the quantities required to give an average predetermined composition should be correctly weighed and actually get into the cupola. This is also true in the case of brass or bronze when melting in the usual crucible furnaces, or latterly in the electric furnace. Furthermore, fuel, if charged with the metal, must also be provided in accurate quantity, so that the melting process may function properly and yield the expected results. Hence the necessity of intelligent supervision at this critical point. Where ordinary labor is entrusted with the weighing and charging operations, an occasional coke charge is either forgotten or doubled, and many a time the wrong kind of pig iron is taken from the yard. Under such circumstances why wonder at poor castings?

In most furnace melting operations it is possible to promote uniformity in metal composition and temperature by frequent rabbling of the bath after the charge has melted down. This is not the case with the cupola, where a considerable part of the day's run is charged before any molten metal is obtained. Corrections are not possible, and hence extreme care is necessary that the individual charges of metal and intermediate coke go in level and uniformly distributed over the area, and that quantities and proportions fit the metallurgical requirements of the melting process.

In the case where the cupola is employed it is essential that the bed upon which the actual melting is done has the proper height to insure the complete utilization of the oxygen of the blast; that in melting the successive charges this bed is not lowered more than about four inches at a time, the replacement by the intermediate coke charges being such that the bed is brought up just right again every time; that this situation is maintained throughout the heat from "blast on" to "drop bottom". With a proper coke ratio, small charges, constant volume blast of proper relation to the cupola capacity, the molten metal should come out white hot and full of "life"—as the foundryman calls it—or "unoxidized," as the metallurgist would put it. Such metal, if the melting stock was of good quality and the gates are cut scientifically, will turn out any casting successfully, and should be striven for by the manager as the touchstone upon which he retains and advances his superintendents and foremen.

Intelligent Supervision in Sorting Room.—The other important place in the foundry fits closely with the above situation; that is, in the sorting room where the bad work is culled out. With bad materials, bad melting, bad gating, singly or in combination, the percentage of defective work rises rapidly. In fact it increases day by day, for the sprues carry an increment of oxidation or other evils from one heat into the next and therefore operate cumulatively. Hence, from a normal of say four per cent of lost work before the machine shop is reached, the figure may soon run up to thirty per cent or more. The man in charge of the sorting room, the man who has the scrapping of bad work must catch the defects before they become serious and urge prompt attention upon his superior. He should be able to distinguish between losses due to molding sand troubles, to bad molding, to cores, or to dull, oxidized, hard iron, etc., and keep a daily record of distribution of losses. In that way the daily sheet quickly shows up a black spot composed of individual marks against some special defect. Calling attention to the responsible man to see this is corrected puts the onus on him to make good, and to do this quickly, otherwise the whole shop and the management itself soon wants to know why. Of what avail is it to turn out molds by the hundred only to lose a heavy percentage of them. Quality work is always cheaper than quantity, within reason. The man sorting out bad work has in his hand the reputation of the establishment, and hence should be a man of parts and not afraid to do his duty.

Good and Bad Features of Machine Molding.—The introduction of the molding machine into foundries has constituted a great forward stride in the replacement of manual labor by mechanical operation. If for no other advantage than this, the change is to be welcomed—for coal is cheaper than muscle. However, just as labor fought the steam engine originally, so it is today still fighting the molding machine by every means possible, no matter what protestations are made to the contrary; and managers must not be disconcerted in extending the use of machine molding wherever it proves an advantage by the open or underhand opposition of the molding fraternity. The work moves on, and whoever opposes its progress eventually gets under the wheels.

With all the advantages of the molding machine in its proper place, two bad features are still outstanding. One is that the operative becomes a human machine, simply registering the several movements automatically, his mind little occupied and intent only on turning out molds in sufficient quantity to get good pay without killing his job. The other objection is that while the molding machine itself is now a very perfect mechanism, the means for removing the finished work from the platen and placing the molds on the floor is an almost untouched problem. The efficient operative of today may have to carry five times the number of molds, and over a wider floor space than was the case with hand-molding. This takes a strong back and means that the manual labor applied during the working day is hardly less than formerly, while the production has been increased tremendously. The

problem of carrying the metal can be solved by the organization of a pouring gang, but the actual handling of the finished mold on the floor still remains. Only in a few establishments has this problem been solved by the use of moving platforms and mold conveying systems. The field is still open for inventive genius for the great majority of foundries that operate today.

Danger of Losing Skilled Men.—With the multiplication of molding machines there is a further danger of deterioration in the number and quality of molders. The present tendency is to break in new men on machines, who when satisfactory are allowed to remain on the several jobs day in and day out. The average foundry superintendent — formerly called foreman—hates to take a man away from a machine on which he is doing well, in order to put him on other kinds of work so that he may perfect himself and become an asset to the shop and himself. And yet this very thing must be done if the art of molding is to live. Modern practice is to replace loam-molding by dry-sand work as much as possible. With the jarring machine and its increasingly understood possibilities, the matter of large cores has also come to the front. Hence the elimination of much of the talent formerly required for successful foundry opertion.

This is all good so far as it goes; for the installation of huge drying ovens, modern core-making appliances and shop rigging planned on a large scale, is obviating much of the skill that was formerly essential. None the less, there should be a fair per-

centage of skilled men in the shop, and these must be trained by the general foundry trade and not in a few shops only. Hence, the far-seeing manager should encourage the trade school, continuation school, public lectures and any form of education which will make men think. The remuneration for skilled work is now so high that the more sheer drudgery is taken from shop routine, and the more a man may use his brain for refinements in bringing out physically perfect molds, the better the class of men attracted and held. Hence molders and helpers should be given the chance to learn all classes of molding operations. Those who remain impervious to progress will remain functionaries the rest of their lives; the few that have it in them move up in responsibility and emolument.

Improvements Effected in Patterns.—Without going into the very special subject of molding machines, one very beneficial effect is felt in every progressive shop. The improvement of patterns and pattern equipment is most noticeable everywhere, particularly in the specialty shops. The pattern shop of today is a vastly different place than was formerly the case. With the constantly increasing use of metal patterns, and the rigging up for molding machines, the patternmaker of today is indeed a highly skilled man, and the investment in his branch of the foundry is a heavy item. The simpler the methods of plating patterns, the greater the number of castings that can be made on a machine economically. The greater the variety of machines in a shop, rather than their number, the more varied the classes of work that can be

successfully performed on them. There is no greater mistake than to suppose that one type of machine will do all kinds of work.

The foundry manager, and similarly his superior, should make it his business to attend the various foundry conventions and exhibits, to study developments with a view of profiting by them. Again, the foremen and superintendents should be sent visiting other establishments to see what the trade is doing. Reciprocity in this is essential, even if there may be a chance of competition, for it is better to be well acquainted with your business rival than to be his enemy. In a properly balanced factory organization, men come home from these inspection tours with full value in information for the expenditure, and always with the feeling that there is no place like the home shop, or better people than the ones who have sent them out to see what others are doing.

Foundry Transportation Facilities.—The study of transportation systems in the foundry is another point that should be kept constantly in mind by the manager. Are there enough cranes over the molding floor? Do they interfere with each other, or are they overworked? Can you put in a number of jib cranes along the side walls or columns to enable a molder to close his flasks without waiting until the only crane in the shop can come along? Idle men cost money. Taking a lot of men away from their jobs to test out a mold before closing it finally means breaking up their routine to some extent. Hence, improvements in the transportation facilities of a shop should always be kept in mind. In the best machine shops,

each tool has burden to carry, and strict account is kept of performances and percentages of time idle. So also in the foundry, although it is not very easy to distribute the work so that the appliances are always operating. Better here a surplus of apparatus than a deficiency. If it is possible to run the railroad cars directly into a shop producing heavy castings, and if the main crane can also cover part of the yard, so much the better. These conditions are not always possible in an old shop, but can be considered when planning to rebuild or move to a new location.

Cleaning Methods.—When the molds have been poured off, the next thing to do is to shake them out. Not only should molds be allowed to stand awhile so that the castings may be black-hot when uncovered, but too much of the sand should not be scraped off, for that immediately in touch with the molten metal has been ruined for further use. The sand has been "burnt", which means that the clay bond of the molding sand has been deprived of the chemically combined water, and the stickiness of the clay is gone forever. Hence this material, injuriously affected to a depth depending upon the thickness of the iron adjoining, should be removed from the floor while on the casting, and cleaned off in the cleaning department of the foundry. It goes to the dump, and is replaced in the sand-heaps by new molding sand.

Cleaning castings is now done in many ways, depending upon the castings themselves and the facilities of the shop. For medium and small work the sand blast is almost obligatory in these days, since customers want to see the surfaces of the castings

and also to have them free from a skin of burnished sand for reasons of economic machining. In quantity work with small castings the old tumble barrel will probably remain if little or no subsequent machining is to be done. Pickling small work also yields results for special purposes that is not excelled by other methods of cleaning. In the case of large work hand labor, supplemented by air operated chisels and grinding wheels, covers the situation.

Whatever process for cleaning is used, the old saying that "prevention is better than cure" applies here as well as in the melting processes. If the sand walls of the molds are properly prepared by a coating of graphite which sticks sufficiently well not to be washed away by the stream of molten metal, they will not adhere to the casting and eventually come away easily, leaving the casting's surfaces smooth and clean. To do this, however, is one of the serious problems of the foundry, and a solution has not yet been found which can be considered entirely satisfactory. Hence, the old method of using a specially prepared "facing" sand to pack up against the pattern for an inch or more and backing this good sand with ordinary sand from the heap, is still in general use. The objection to this facing sand lies in the fact that it contains a considerable amount of finely ground gas coal—called sea-coal—which on contact with the molten metal forms a thin layer of gas between sand and metal for the moment. While the result is a smoother surface, particularly if a coat of graphite has been put on in addition, the returned sand after shaking out has had its bond damaged by

the exceedingly fine coal dust, and therefore the sand heaps deteriorate. Eventually some method will be found to apply graphite to a mold surface so that it will stick under all conditions, then the use of sea-coal will be a thing of the past.

Some Points in Core-Making.—While it is axiomatic that any intelligent man picked up from the streets can be taught core-making quickly, and hence the wages paid in the core room today when contrasted with those given skilled molders are preposterous, nevertheless the guiding head of the core room must be well informed. Cores must be made of materials compounded to suit the requirements of the casting. The fundamental condition is that a core should stand up under the stream and pressure of molten metal without yielding long enough to allow the metal to set, and then be sufficiently destroyed to be easily removable. Since metals and alloys contract on cooling, unless a core can yield a little when this final contraction takes place, the casting is apt either to crack or be so full of casting strains that it is weak and really should have the benefit of an anneal. Where the metal has been oxidized in the melting, a hard core is almost certain to crack a large casting which entirely surrounds it, as such damaged metal will not stretch in the setting. Hence the advisability of holding the clay content of the core sands used to a minimum, as these make for a hard core.

The usual mixture of part old cores, molding sand and new core sand free from clay should be watched, for the ideal core is made of a rough-grained beach sand, free from clay, with just enough core-binder to

hold it together properly. Such a core will vent splendidly—that is, allow gases to pass through it—and be easily removable in the shaking-out process. Modern core rooms are equipped with coremaking machines, drying ovens with regulation of temperature conditions, racks on wheels, mixing machinery, good benches for the operatives, plenty of light and ventilation, and storage facilities.

Since the binder for cores is usually applied with water, the process of "drying" rather than baking a core is divided into two stages. The first is the removal of the moisture, which presupposes ventilation within the core oven to allow the water vapor to escape up the chimney. Second is the ability to raise the temperature so that the best working heat be given the cores as required by the particular binder used. In general it is best to give just a little more heat than is necessary for the best strength, as this will aid in preventing an absorption of moisture later on when the core is set in a green-sand mold, or is stored for future use. A good core room foreman should be selected, for he should be able to do considerable experimenting with mixtures and binders so that he can bring out a line of cores just adapted for the requirements of each case and with due regard to plant economy.

Difficulties Due to Contraction of Metals.—A plant manager will do well to remember that there is a constant warfare—friendly or otherwise—waged between the pattern shop and the foundry on the one hand, and between the foundry and machine shop on the other. This lies in the nature of things. The suppo-

sition is that iron contracts after setting at the rate of about an eighth of an inch to the foot. Brass, aluminum, and other metals and alloys contract similarly, but with different figures. Practically, however, much depends upon the shape of the casting, the condition of the cores, and other circumstances, so that some parts of a casting will be found to have contracted more than others. Popular parlance has it "shrunk" instead of contracted, but a "shrink" is the tearing apart of metal inside the casting where the last liquid metal remained unable to be replenished through the gate or riser; whereas the "contraction" that must be figured on when making a pattern takes place after the casting has set altogether, and is the reduction in dimensions from red heat to the cold state.

Now, since the amount of contraction will vary in a casting, the foundryman will blame the patternmaker when the castings do not measure up correctly, and the patternmaker will claim his work is all right. So also with the machine shop where the castings are wanted soft enough to machine easily. This the foundry cannot always give, for to do so would require theoretically that each casting have a different composition to give the best qualities, and only one or two mixtures can be run safely from a cupola, and only one from a furnace.

The differences between pattern shop and foundry lend themselves to adjustment as experience piles up. The ordinary custom where a number of castings from the same pattern are to be made is to mold up and pour one, measure it up carefully, and then

change the pattern to give the correct final results. In the case of foundry versus machine shop, however, the adjustment of trouble requires a lot of tact, for the foundry man really has much to contend with. In making the mixture attention is given to the demands of the lighter sections of the castings to be made. The aim is to get these soft enough to machine without too much difficulty. The heavier sections will then surely be soft enough. Unfortunately, however, these heavier sections will be weaker than may be wanted, and hence a harder iron will have to be made in spite of the machining qualities involved. Herein lies the difference between American and European practice. In the former machinability is demanded above almost everything else, for the factors of safety used are large. In Europe, however, they have to deal with closer cost margins, and hence a casting is made to serve its purpose whether machining is difficult or not. In the larger foundries of America this question is generally handled by leaving the determination of the mixtures to the care of the metallurgist who has to find the dividing line between service and machinability. Unless the metallurgist is a man of ability and tact, he has an excellent opportunity of being in hot water with both foundry and machine shop.

Keeping Watch on Costs.—In the course of the various foundry operations it is necessary that costs be watched closely. A complete system of forms for getting productive and non-productive labor costs; forms for following up the patterns and shop orders for castings to be made, material requisitions, and

any number of data may be wanted to give the correct answer to any question connected with the production end. There is danger in multiplying this too greatly just as much as allowing leaks to pass unobserved. There must be a practical reason for every bit of information wanted day in and day out, otherwise the foundry office will become top heavy with clerical help. When boiled down to departmental costs per hundred pounds, with overhead clearly indicated, and so on, the manager can have his fingers on the pulse of the establishment constantly, and while knowing exactly what is going on, prepare for what his vision should tell him is ahead.

Observation of Manufacturing Tendencies. — This brings the subject to the point of judging what is ahead. Men of affairs in any industry connect themselves not only with their respective representative bodies, but also with local and further reaching bodies of financial men, so that they may learn the trend of money, commodity production, the disposition of labor, transportation service and a thousand other things that affect business life. These things cannot be learned in the establishment itself. The salesmen bring in reports of coming conditions and movements, and the ear must be kept to the ground. In the shop itself, however, there should be the means of knowing ahead what lines of operation the industry is tending toward. Visits of the superintendents and foremen should disclose this. Each man should give much of his spare time for private study of books and journals so that he can tell the manager what he sees coming rather than be told it. The

laboratory is one of the best places for exchange of thought between the technical staff and the men who guide operations. Our large industrial establishments recognize this, and either instruct the foremen to drop in at the laboratory now and then or else everyone of importance lunches at the same time and place.

A good plan is to have the numerous journals that sift into a plant by subscription or otherwise directed first to the laboratory. The metallurgist should then skim over the content, digest and mark pertinent articles, and pass them on to those most interested. Reports should be sent as memoranda to the manager for his files, so that he may know the gist of an article or be able to call for it. In time, a respectable library is thus accumulated which becomes invaluable in planning changes or otherwise increasing the efficiency of the establishment. Our modern works seldom look as they did a decade ago apart from the expansion side. Methods change, the public taste or requirements change, and the manufacturing plant that does not adjust itself to the times eventually has to leave the field. Fortunately plant changes are not made overnight, and the purchasers of the product have eventually to pay for these changes.

Keeping the Plant Up-to-Date.—Probably the best way to handle the general plant situation—unless new discoveries or exceptional circumstances require it otherwise—is to do as wise township officers handle the road problem. Instead of patching up indiscriminately and having a road system always on the point of breaking down, a considerable portion of the available funds is spent at one or more points as part of a

first-class permanent way. The balance of the money is spent in upkeep for the rest of the roads. So also in a foundry: An appropriation should be made every year for the thorough reorganization of a single department—from the ground up. For instance, a new core room is built, in every respect up to date and of ample capacity for years to come. The rest of the plant is kept in the shape that is required. As, year by year, a plant is thus improved in its several departments, it cannot help but be fairly up-to-date all the time. Advantage will naturally be taken of the times. Building when everything is high is out of question, but during times of industrial depression is just the time to get ready for the following expansion which is certain to come. Pig iron can be contracted for similarly, and the yard can be stocked up heavily. When the rush comes, the material is at hand to produce promptly and with good raw materials—a thing which is not possible when no provision has been made and resumption comes on unexpectedly.

The foundry is a place in which an endless variety of things happen. The forces of nature are made to yield in many ways. Safety must be watched for instinctively by every one at work. There is danger everywhere. The reward is not large but it is satisfactory, and there is a consciousness that not every one can win out against the refractory character of the inanimate things encountered. All the more the satisfaction of those who do. The high points only have been touched in what has been given, but it is the hope of the writer that the view shown of a wonderful industry has been of some value.